

Failed optical afterglows

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Abstract. While all but one Gamma-Ray Bursts observed in the X-ray band showed an X-ray afterglow, about 60 per cent of them have not been detected in the optical band. We show that this is not due to adverse observing conditions. We then investigate the hypothesis that the failure of detecting the optical afterglow is due to absorption at the source location. We find that this is a marginally viable interpretation, but only if the X-ray burst and afterglow emission and the possible optical/UV flash do not destroy the dust responsible for absorption in the optical band. If dust is efficiently destroyed, we are led to conclude that bursts with no detected optical afterglow are intrinsically different.

1 Observations

Figure 1 shows magnitudes of the detected bursts and upper limits of failed optical afterglows (FOAs), all in the R band, versus the time of observation. Filled and empty circles correspond to *BeppoSAX* and non-*BeppoSAX* bursts with detected optical afterglows, while arrows are upper limits.

The visual inspection of Figure 1 reveals a clear segregation of arrows from dots, the former being systematically fainter than the latter at comparable times. This impression is confirmed by the application of a bidimensional KS test (Press et al. 1992). The probability for the circles (empty + filled) and the arrows being derived from the same parent distribution is $P \sim 0.2$ per cent.

This result shows that in most cases we failed to detect the optical afterglow not because the search was conducted without the necessary depth, but instead because the FOAs are indeed fainter than the detected ones. Yet, it is possible that FOAs are optically fainter because intrinsically less energetics at all wavelengths, or because they are more distant. In order to check this, we compared the X-ray and R band flux densities of bursts with and without optical detection 12 hours after the burst event, finding that the X-ray fluxes of FOAs are not systematically fainter than the fluxes of afterglows with optical detection, indicating that FOAs are indeed optically poor and define a different population with respect to optically detected afterglows.

We have checked that local Galactic extinction does not play a crucial role by comparing the hydrogen column densities in the direction of detected afterglows with those in the direction of FOAs.

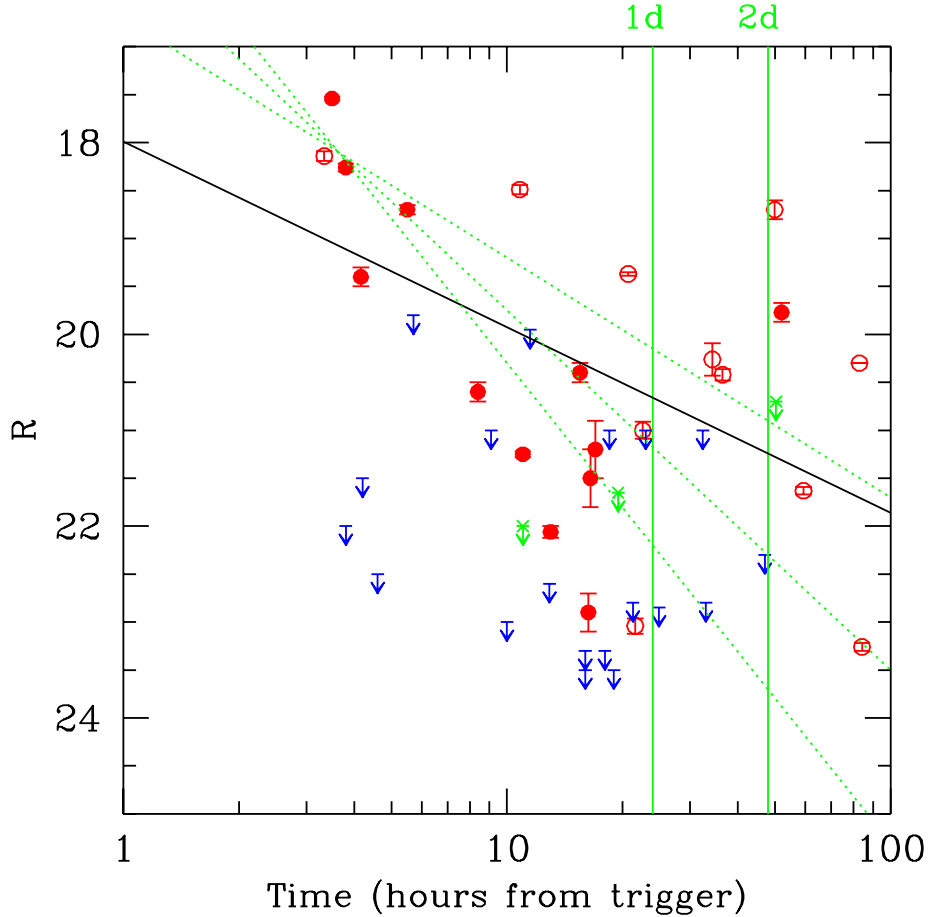


Fig. 1. Detection R magnitude (or upper limits) versus the time of observation for a set of afterglows. Filled circles show optical detections of *BeppoSAX* afterglows while empty circles show detections of non *BeppoSAX* afterglows. Arrows show upper limits for *BeppoSAX* failed optical afterglows. Arrows with crosses refer to the upper limits on γ -ray poor X-ray transients detected by *BeppoSAX* (their inclusion/exclusion from the sample does not alter any of the presented result). The dark solid line is the best fit for the magnitudes of detections vs. time. Dotted lines show the $F_\nu(t) \propto t^{-1}$, $t^{-1.5}$ and t^{-2} relations. From Lazzati et al., 2001.

2 Intrinsic Absorption?

We have investigated the possibility that the difference between the two groups is due to absorption local to the burst. We can quantify in roughly 2 magnitudes the amount of average absorption in the R band needed for more than half of the bursts to go undetected in the optical.

Can a typical molecular cloud produce such an absorption in more than half of the bursts? In order to answer this question we (Lazzati et al. 2001)

have computed the *average* (i.e. over many line of sights) and the *maximum* absorption of known molecular clouds in our galaxy, taking into account that observations of bursts in the *R* band actually correspond to light emitted at shorter wavelengths, where extinction is more effective. Since the redshifts of FOAs is obviously unknown, we have assumed $z = 1$ for all of them.

Our results can be summarized as follows:

- If the burst is located at random within a molecular cloud, it will on average be absorbed with the mean value of the cloud absorption. In this case we found that only a few percent of the burst afterglows could be missed for this reason.
- If bursts are located in star forming regions, then they lie in the densest parts of the cloud, i.e. those with maximum absorption. In this case it is (albeit marginally) possible that up to 60 per cent of the bursts have optical afterglows sufficiently absorbed to have avoided detection. But consider that we have been very conservative in our procedure, because our results are based on considering *upper limits* on the optical flux, and *peak* absorption columns expected in giant molecular clouds.
- The latter assumptions may well be too conservative, if the dust is bound to evaporate when illuminated and heated by the powerful optical/UV flash of the gamma-ray burst (Waxman & Draine 2000) and by its X-ray radiation (Fruchter et al. 2000). This dust sublimation is suggested for a sample of burst afterglows (Vreeswijk et al. 1999, Galama & Wijers 2000), in which a very large hydrogen column density $N_{\text{H}} \gtrsim 10^{22} \text{ cm}^{-2}$, as estimated by X-ray data, is associated with almost no optical extinction. The results can be understood only in terms of a dust to gas ratio ~ 100 times smaller than the Galactic average value. In turns, such low values of the dust to gas ratio can be explained only if the dust has been completely sublimated in the surroundings of the burst. Indeed the theoretical models mentioned above predict that dust can be destroyed by the burst emission out to a radius comparable to the dimension of a typical molecular cloud (up to a few tens of parsecs). If this is the case, the material responsible for absorption in FOAs is not the overdense cocoon surrounding the star forming region, but the cloud as a whole (or even less), and the discrepancy between the observed and measured value becomes extremely compelling.

References

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